"Tyre track"

The present invention relates to a monolithic flexible track aimed at being used for converting a wheeled vehicle into a tracked vehicle. The term monolithic is used herein as opposed to a track composed of a plurality of connected rigid elements extending in cross direction of the length of the track, the rigid elements being embedded in a rubber phase or not.

In the past, a vast number of solutions have been proposed for converting a wheeled vehicle into a tracked vehicle, according to which a monolithic flexible track is installed around a pair of wheels remote from each other on the same side of a vehicle, at least one of the wheels being a driven wheel. To prevent elongation of the track during use, the track is usually reinforced in longitudinal direction, for example by one or more steel or textile fibres or cords.

In GB-A-2.104.015 a flexible endless track is disclosed, which is made of an elastomeric material reinforced with nylon or steel filamentary material in the form of a continuous cord wound across the width of the track in a plurality of side-by-side turns. As this track is an endless, continuous one, the tires of the wheels need to be deflated when mounting the track thereto. This operation is complicated and time consuming. Of course, the complementary operation of removing the track from the wheels presents the same disadvantages.

Another solution for adapting a wheeled truck having the tires arranged in sets of two adjacent tires, to agricultural purposes and to make it suitable for travelling with heavy loads on weak soil has been proposed by US-A-4.362.340. According to US-A-4.362.340 an endless tread type track is mounted around a pair of consecutive tires, the track being made of a flexible material, for example synthetic resin or rubber-like material, if so desired containing one or more canvas or nylon liners. The track is built up of a single part, both ends of which are interconnected when mounted to a vehicle to form an endless belt. The

track may however also be built up of two or more parts, which are connected to each other by two or more joints. On the inner side of each belt, i.e. the side facing the tires, a plurality of cams or teeth having the shape of a truncated pyramid is provided. The cams or teeth are held in a clamping fit between two adjacent tires.

An analysis of the problems arising with this type of tracks based on circumferential traction of the track by the wheels, has revealed that to provide sufficient traction, the length of the track needs to be adapted to the size of the wheels and the distance between the front and the back wheels. As with different vehicles the size of the wheels varies, and as tires wear out when in use, a continuous adaptation of the circumferential tension is required. Besides this, the traction provided by the cams appears to be insufficient, slipping at the front side of the vehicle being the result.

In DE-U-9302375.8 a flexible belt for use as a track is disclosed, which solves the problem of minimising the risk to elongation following use, as this adversely affects the contact between the track and its driving. The flexible belt disclosed in DE-U-9302375.8 is provided to be used as such, there is no teaching to use this belt in combination with a wheeled vehicle. The belt disclosed in DE-U-9302375.8 comprises a plurality of parallel bands connected to each other in cross direction of the track, each band being internally reinforced by a plurality of metal cords. The coupling of parallel bands in cross direction of the truck is achieved by means of a plurality of U-shaped profiles, each U-profile being received in corresponding recesses in the parallel bands. Each band has an opposite first and second end part. Each end part contains a central coupling hole for coupling the first end part to the second end part in longitudinal direction of the track, a reinforcing cord extending as a loop around the coupling hole.

There is thus a need to a flexible track for converting a wheeled vehicle into a track vehicle, which may be easily mounted and shows an improved driving of the track by the wheels.

It is therefore the aim of the present invention to provide a flexible track for converting a wheeled vehicle into a tracked vehicle, in which an optimised transfer of driving forces from the vehicle to the flexible track is achieved.

This is achieved according to the present invention with a flexible track which comprises a band of flexible material provided for mounting around at least two successive vehicle wheels, taken in the movement direction of the vehicle. The band of this invention has a first and a second end part which extend in cross direction of the band and comprise mutually co-operating connecting means for connecting the first end part to the second end part with the aim of forming an endless track. The flexible track of the present invention is characterised by the presence of a plurality of guiding wings spaced apart from each other and disposed along opposite longitudinal sides of the band. The guiding wings protrude from the inner surface of the band facing the wheels so as to form a channel which is aimed at engaging opposite lateral sides of at least part of the vehicle wheels.

The presence of the guiding wings along the sides of the track counteracts de-tracking of the track from the wheels when the track is driven in extreme conditions. The inventor has namely observed that when loaded, the wheels expand in lateral direction, as a consequence of which the sides of the wheels contact the guiding wings and are forced against the guiding wings. The friction forces in width direction of the belt arising from such contact ensure an improved grip of the track to the wheels and a consequently reduced risk to slipping. The reduced risk to slipping has been observed even in case little or no circumferential stress is exerted by the track, where the track showed some sagging, as well as in severe circumstances with heavy grounds. The positive driving of the track by the sides of the wheels reduces the sensitivity of the driving to wearing of the running surface of the tires and has the effect that the need to circumferential tension for driving the track may be dispensed with. The optimised contact surface between the wheels and the track contributes to this effect.

In addition to the optimised transfer of driving forces from the vehicle to the flexible track, the inventor has observed that the driving forces needed are virtually independent of any possible wearing of the tyre and circumferential tension exerted by the track, contact pressure distribution being optimised, the track being easy to fit.

An analysis of the problems arising with continuous tracks to be mounted around wheels has namely revealed that when aiming at driving the

track through circumferential traction, the track needs to fit closely around the wheels. A good fit can only be obtained if a serious circumferential stress is exerted to the wheels. This stress however imposes heavy loads to the parts connecting the end parts of the track and often involves in a fast break down of these connecting parts. The analysis has also revealed that driving of the track provided through mechanical engagement of the running surface of the wheels by protrusions on the inner side of the track is insufficient, and that the problem of slipping of the track still arises if the band does not fit sufficiently tight around the wheels.

Conversion of a wheeled vehicle into a tracked vehicle is done in circumstances where there is a need

1) to decrease the local pressure exerted by the vehicle to the soil and,

2) to have the ground pressure exerted by the track as uniform as possible, in order to minimise soil compaction.

The use of a continuous track contributes to decreasing the pressure exerted by the vehicle to the ground in a more or less uniform manner, as a consequence of which the risk to the occurrence of a too high local pressure is also minimised. Furthermore, an improved contact with the ground surface and an improved contact floor pressure have been observed, especially in case rubber tracks are used which are substantially free of holes. These improvements are important as the tracks of this invention are meant to be used on muddy grounds, where there is a risk to sinking into the ground when loaded, on sandy grounds, on steep slopes or on rocky surfaces. Besides being capable of moving over such grounds, the vehicle must further be capable of picking up, moving and carrying loads. These actions put high demands to the ground pressure exerted by the vehicle. It has been observed that when using a vehicle having the track of this invention mounted to the wheels, there is a strongly reduced risk to toppling over of the vehicle during use.

Furthermore, an optimum discharge of stones and parts, accidentally ending up between the wheels and the track, has been found. This phenomenon can be explained by the fact that due to the low circumferential tension, exerted by the tyre in the non loaded position maintains its substantially round cross sectional shape. The presence of a crowning on the contact

surface of the wheels combined with the predominantly square and flat inside shape of the track creates vectorial forces in the crowning, which are directed to the outside, causing stones and other debris to move outwards. As can be seen from figure 7 the radial component of these vectorial forces reduces towards the outside while the axial one increases.

Due to the presence of the connectable end parts, an easy mounting of the track is guaranteed.

To improve the driving forces exerted by the wheels to the track, it is preferred that the guiding wings are arranged to exert a clamping force on the opposite lateral sides of the vehicle wheels. Furthermore, it is preferred that the guiding wings show some resilience, as this renders the use of the track less dependent from the width of the wheels.

However, when it is preferred to minimise the flexibility of the guiding wings, each guiding wing is preferably reinforced with a rigid core. The rigid core may for example be made of steel or any other suitable material. The rigid core is preferably composed of two substantially perpendicular disposed portions, a first transversally extending portion, the other portions extending substantially perpendicular thereto in the guiding wing. The presence of the rigid core counteracts flexion of the guiding wings in width direction of the track, thus increasing friction forces between the wheels and the guiding wings as the wheels expand when loaded.

The inner side of at least part of the guiding wings faces the wheels and is provided with profiles protruding from the inner side towards the wheels in order to improve the grip to the wheels and to minimise the risk to building of frictional heat.

At least part of the outer side of the guiding wings is provided with profiles protruding from the outer side in order to improve grip of the band to the ground.

The guiding wings can be made of the same flexible material as the material of which the track is made, or of a different material. Preferably however there are made of the same material.

A further improvement of the transmission efficiency of the displacement of the wheels to the track is achieved if the inner face of the band aimed at contacting the wheels, is provided with traction ribs. The traction ribs are

disposed so as to allow engagement of corresponding recesses present in the vehicle wheels, especially in case unwanted slipping of the wheels on the track occurs. As a result of the traction ribs engaging the wheels, the circumferential tension exerted by the track to the wheels can be reduced, which is beneficial to the transmission of the power of the engine on the ground through the tracked wheels, even in case of sagging of the track.

The number and shape of the traction ribs and the engagement aimed at will be adapted by the man skilled in the art to the circumstances in which the track is to be used. It is generally advise to allow some slipping, especially when with heavy grounds the power needed to drive the vehicle would become higher than the motor power.

In stead of or in addition to traction ribs, a plurality of protrusions may be provided on the inner side of the track. The number, shape and pattern in which the protrusions are arranged will be adapted by the person skilled in the art to achieve optimum engagement of the wheels.

To improve the flexibility and pliability of the track it is important that the track may flex at the position where the first and second end part are connected to each other. To achieve this the first and second end part of the band are hingingly connectable to each other.

Furthermore, to improve the strength of the track, at least one flexible elongated reinforcing element is embedded in the band. This at least one reinforcing element extends along the length of the said band and forms a loop around the hole or holes provided at the position of each of the first and second end part of the band.

In the flexible track of this invention, each reinforcing element comprises a first and a second end part, each of the end parts being secured to the reinforcing element to form a loop. The presence of the loop provides an additional reinforcement of the end parts of the track. The presence of the loops has the effect that the tension forces endured at the connection of the two end parts of the track in operation of the track, will be absorbed by the flexible elongated reinforcing element. In that way the risk to the formation of cracks in the elastomeric band at the sides of the passage receiving the connecting means for the two end parts, may be minimised.

Suitably, the band comprises opposed first and second lateral longitudinal sides and each reinforcing element extends continuously from one longitudinal side of the said band to the opposite longitudinal side of the band in making alternate loops around each hole of each of the first and second end parts of the band. This configuration provides the track with an homogeneous traction resistance, especially at its end parts, since each passage for receiving connecting means for connecting the end parts of the track, will be properly reinforced.

The shape of the reinforcing element is not critical to the invention and will be adapted by the person skilled in the art depending on the intended use. It may however be preferred to use a reinforcing element comprising at least one metal or textile cord or strip, as these materials show a high tension resistance and a high flexibility. More preferably, the reinforcing element is composed of a steel cord strip embedded in an elastomeric material coating; or a plurality of adjacent steel cords embedded in the elastomeric material coating.

Because of the presence of the loop in the longitudinal reinforcing elements and the distance which exists between adjacent reinforcing elements embedded in the elastomeric matrix, the longitudinal moment of inertia can be increased. This has the result that a higher bending resistance in longitudinal direction of the track may be achieved, which in turn involves a more uniform distribution of the ground pressure exerted by the track.

In a preferred embodiment of the invention, the first and second end parts of the band are provided with alternating extensions and recesses, each extension being provided with at least one hole. Each extension of the first end part is provided to engage a corresponding recess of the second end part, each extension of the second end part is provided to engage a corresponding recess of the first end part. In that way, at the position where the first and second end part engage each other, a channel of successive holes is formed for receiving the connecting means for connecting the first and second end parts of the band. This embodiment provides a very simple means for connecting the end parts of the band, affords a strong bonding of the end parts to each other and provides in an outstanding continuity of the track once mounted on wheels of a vehicle. An optimum of the amount of alternating extensions and recessions

can be determined by the man skilled in the art and is related to the strength of the reinforcing element and the diameter of the connecting rod.

The size of the connecting means is preferably selected such that it corresponds to the formula:

$$d \geq \sqrt{(6 / \pi * \{(x * y) * F_{breaking}\} / \{ (x - 1) * \sigma\ 0.2 \})}$$

in which

$F_{breaking}$ = breaking load of longitudinal reinforcing element (7) i.e. steel cord, textile, fiber, ... (16) measured per separate cable, literature values)

x = the number of loops of reinforcing element (7)

y = cables / section (fig. 2c)

the ratio between the number of and the cable

σ 0.2 = tensile strength of the connecting means (13)

τ_{max} = 1/3 σ 0.2 (see literature)

d = diameter of the connecting means (13)

$$\tau = \{ (x/2 * y) * F_{breaking} \} / \{(x-1) * \pi * d^2 / 4 \}$$

$\tau \leq \tau$ max

$\tau \leq 1/3\ \sigma$ 0.2

In practise, for example the value of the above mentioned parameters may be as follows:

F	6700 N	
x	11	
y	6	
SIGMA	470 N/MM^2	(STAINLESS)
D	12,78423952	

With the above described technical features a substantially monolithic flexible track may be obtained, that can readily be mounted to or removed from a vehicle. The track of this invention is a non continuous one, which is composed of flexible material reinforced with a liner of nylon, canvas or the like, embedded in the track. The non-continuity with the connectable opposite end parts enables an easy mounting of the track to the vehicle wheels, for example by driving the vehicle on top of an open, depleted track, i.e. a track with the end parts not connected, until the tyres are positioned at inside of the tracks, followed by fastening the end parts together around the wheels.

Suitably, the means for connecting the first and second extremities of the band comprise at least one rigid or flexible elongated member having a length corresponding to the width of the band and having a cross section adapted for passing through each hole of the first and second end part of the track. This enables a fast and easy connection of the said extremities.

It is preferred that each of the holes is provided with a rigid tubing section. This ensures that passage for receiving the means for maintaining connected the extremities of the band conserves its shape even when the said extremities are submitted to high tension forces.

When in operation, especially when the track has to drive in heavy ground conditions, the part of the track where the first and second end part of the track are connected to each other, is subjected to high tension. By having each passage at the first and second end part of the track reinforced with a reinforcement material embedded in the track, the risk to the formation of cracks in width direction of the track as a consequence of the occurring stresses, may be minimised. It shall be understood that the occurrence of such cracks would weaken the rigidity of the track and involve the risk to breaking of

the track, ensuing a serious risk to the driver of the vehicle and the people in his vicinity.

Either only one or both end parts of the track may further be provided with a rigid bush, for example a moulded rigid bush, the rigid bushes of the first and second end part being made so as to engage each other. The rigid bushes can be moulded in an elastomer and may for example be formed by alternating rectangular extensions and cavities. Preferably each moulded extension comprises a hole for receiving a tubing section. When the first and second end parts of the track engage each other, the tubing sections form a substantially uninterrupted channel for receiving a rod, for example a steel rod, aimed at connecting and fastening the first and second end parts of the track in view of forming an endless belt around the vehicle wheels.

In another embodiment of the invention, the track further comprises additional rigid or flexible reinforcing elements disposed across its length. This provides the band with an improved transverse stability, reduced risk to wearing and improved resistance to impact damages. This is important when the vehicle on which the track according to the invention is mounted has to progress in heavy and highly irregular ground conditions and a uniform distribution of the pressure exerted to the ground is aimed at.

Possibly, the flexible track according to the invention further comprises at least one intermediary piece being removably connectable at the said first and second extremities of the band in view of modifying the length of the track. This enables the said track to be adapted to nearly any configuration of wheeled vehicles.

The invention will now be further detailed in the appending drawings and description thereof, in which :

Figure 1 represents a partially exploded perspective view of a portion of a track according to the invention mounted on a wheel of a vehicle.

Figure 2a represents a perspective view of a flexible elongated reinforcing element of a track according to the invention.

Figure 2b represents a perspective view of a loop formed by a flexible elongated element according to the invention.

Figure 2c represents a front section view of the flexible elongated reinforcing element according to the invention.

Figure 3 represents a perspective view of a portion of a track according to the invention in a position in which the extremities of the band of the track are connected.

Figure 4 represents a top view of a portion of a track according to the invention.

Figure 5a and 5b are preferred embodiments of the inner surface of the track of this invention.

Figure 6a and 6b show preferred embodiments of the outer side of the track of this invention.

Figure 7 shows forces arising in a wheel contained in a track of this invention.

Referring to figure 1, there is shown a portion of a flexible track 1 according to the invention, mounted to a tyre 12 of a wheel of a wheeled vehicle (not shown). The track comprises a band 5, the band being made of a flexible material. The band may be made of any suitable material known to the man skilled in the art, but is preferably made of elastomeric material.

Into the material of the band 5 at least one reinforcing element 7 is embedded. The reinforcing element 7 may be made of any suitable material known to the man skilled in the art, and may for example be made of a steel cord strip or a plurality of adjacent strips of such material embedded in an elastomeric material coating. Other suitable materials include strands, tows, yarns or fabric strips of fibres of a reinforcing material, comprising for example mineral fibres, metal fibres, synthetic polymerfibres for example polyesterfibres, for example aramid fibres. It is however also possible to combine reinforcing elements made of different materials. The reinforcing element 7 extends along the length of the track 1.

The track further preferably comprises a single or a plurality of flexible reinforcing elements 11 extending from a first longitudinal side of the band to a second longitudinal side of the band 5. This reinforcing element provides a protection shield against puncture and damage from outside bodies and implies the desired longitudinal stiffening to the track.

The track 1 also comprises a plurality of guiding wings 4 which protrude from the inner face of the band 5, i.e. the side facing the wheels. The guiding wings 4 are disposed along the longitudinal sides of the band 5. The distance

between adjacent guiding wings 4, the shape and height of the guiding wings and the positioning along the opposite sides of the band will be adapted by the person skilled in the art depending on the intended use. The guiding wings may be made of any suitable material known to the man skilled in the art, but are preferably made of the same material as the band 5. The guiding wings 4 are provided to engage opposite lateral sides 22 of the wheels of a vehicle to which the band is mounted and to exert a clamping force on the said sides 22.

Depending on the circumstances in which the track is to be used, each or part of the guiding wings 4 may be reinforced with a rigid, semi rigid or flexible core 6. The core 6 may be made of any suitable material known to the man skilled in the art, for example a thermoplastic or thermosetting resin, a fibre reinforced composite material, a metal part, although the use of steel is preferred. The rigid core will usually comprise (a) a first base part which extends in cross direction of the track and in use runs parallel with the running surface of the track 1, and (b) two portions extending substantially vertical with respect to the base part, although the angle may be smaller than 90° if higher clamping forces are aimed at.

The inner side of the guiding wings 4 facing the wheels preferably contains protrusions, for example profiles or patterns, which protrude from the inner side in the direction of the wheels. This is done to improve grip to the wheels and to reduce the risk to building of frictional heat in the wings 4. Furthermore also the outer face of the guiding wings 4 may comprise protrusions, for example profiles or patterns protruding from the outer face so as to improve the grip of the wings 4 to the ground over which the track 1 is displaced. The preferred shape of the profiles will be determined by the man skilled in the art.

The guiding wings may be made from another material then the main body of the track.

The guiding wings 4 can be used as such or in combination with traction ribs provided on the inner side of the band facing the wheels. When used alone, guiding wings 4 enable any kind of design of the tires of the wheels of the vehicle to be used, provided the width of the tires is adapted to the track. Traction ribs could either be used as universal additional traction elements allowing occasional positive interference when slipping occurs. The shape,

number and position of the traction ribs will be determined by the man skilled in the art taking account of the specific tire design, so as to guarantee optimum male / female engagement.

In figure 2a there is shown the flexible elongated reinforcing element 7. The reinforcing element 7 shown consists of a steel cord coated with a layer of an elastomeric material. The thus coated reinforcing element 7 is embedded in the material of the band 5 (not shown) of the flexible track 1. The flexible elongated reinforcing element 7 extends continuously from one lateral side of the band to the opposite lateral side. This is achieved in that a first end part of reinforcing element 7 extends from the first end part 18 of the track towards the opposite second end part 19 of the track, makes a loop around the second end part 19 and returns to the first end part 18 to make another loop around the first end part 18. In that way the reinforcing element 7 makes alternating loops around the first 18 and second end part 19. Preferably these loops extend around rigid tubing sections 9 which delimit holes 14 provided at the end parts of the band. The holes 14 extend in cross direction of the band for forming a passage for receiving connecting means (not shown) for connecting the first and second end part of the band as shown in figure 3.

The reinforcing element (7) is made of metal, textile, a plastic material, mineral fibres, metal fibres, synthetic polymer fibres for example polyester fibres, for example, or aramid fibres, or a combination of reinforcing elements made of different materials preferably embedded in an elastomeric material coating (17), cord or strip or a plurality of adjacent strips of such material embedded in an elastomeric material coating.

The reinforcing element (7) takes the form of a cord, a strip, strands, tows, yarns or fabric strips of fibres of reinforcing material.

The band comprises a plurality of rigid or flexible reinforcing elements (11) disposed across the length of the band.

The end parts 8 of the reinforcing element 7 are secured to the reinforcing element 7 to form the loop and to provide for a transfer of stresses from the end part to the bulk of the reinforcing element.

Figure 2b shows a detail of a loop made by the flexible elongated reinforcing element 7 around a rigid tubing section 9 delimiting a hole 14 for the

passage of a means (not shown) for connecting the extremities of the band (not shown).

Figure 2c shows in front section a the flexible elongated reinforcing element 7 comprising a strip of a plurality of steelcords 16 embedded in an elastomeric material coating 17.

Figure 3 shows a portion of a flexible track 1 according to the invention comprising a band 5 of elastomeric material, as well as the first and second end part 18, 19 connected to each other. As can be seen from figure 3, each of the first and second end part 18, 19 comprises a plurality of alternating extensions and recesses 2. Each extension of the first end part engages a corresponding recess of the second end part. Each extension is provided with a hole in which a tubing section is mounted (not shown), such that that tubing sections of successive extensions form a channel 15 in cross direction of the band for receiving connecting means (not shown) for connecting the end parts of the band 5. It is preferred that the first and second end part (18, 19) of the band (5) are hingingly connectable to each other.

Figure 4 shows a portion of a flexible track 1 according to the invention, comprising a flexible band of an elastomeric material 5 having guiding wings 4 and tractions ribs disposed at the inner face of the band 5 which is aimed at contacting wheels of a vehicle on which the track is to be mounted. Shown on the figure is an extremity of the band 5 provided with alternating extensions and recesses 2, each of the said extensions having a hole 14 delimited therein in cross direction of the length of the band for forming a passage for receiving a means 13 for connecting the extremities of the band 5 when the track is mounted on wheels of a vehicle, the said means 13 consisting in a rigid elongated element.

As can be seen from figure 5a and 5b, besides or in stead of traction ribs, the inner face of the band may be profiled so as to improve engagement between band and tyres if necessary.

As can be seen from figure 6a and 6b the band comprises a profiled outer face 10 which is optimised to any type of application or ground condition. The outer face may further comprise at least one transversal lug, angled lug, bended lug, diamond or block pattern, slick embedded in bolt on or fixed to the

track made of rigid material, with the aim of improving the grip to the ground or reinforcing the band and increasing its lifetime.